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Conference Abstract

Modelling Freshwater Fish Species' Distributions Considering the Impact of River Fragmentation in Mainland Spain

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Abstract

Over one quarter of freshwater fish species are threatened with extinction, and the presence of dams and water management affects almost half of these species (Sayer et al. 2025). Man-made barriers like dams or weirs fragment the river network and alter habitat characteristics such as flow, sediment, nutrients, and temperature regimes (Maavara et al. 2020, He et al. 2024). As a consequence, there can be declines in habitat suitability for certain species, reflected in changes in species richness and composition (He et al. 2024). Moreover, the movement of fish along the river is hindered, making the access to spawning and feeding grounds difficult and reducing the genetic flow between populations (He et al. 2024). Species Distribution Models (SDMs) are a widely used conservation tool that allow us to explain and predict the geographical distribution of species based on their relationships to environmental covariates. They can be used to make inferences on environmental relationships (Guisan et al. 2017). The aim of this study was to model the distribution of the brown trout (*Salmo trutta* Linnaeus 1758), a

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migratory freshwater fish, in mainland Spain, taking into account the impact of river fragmentation.

A detailed river network, divided into 432,099 river segments, each with associated hydrologic, climatic, topographic and geological variables (hereafter, environmental variables), was used to build the models. Barrier data was extracted from European, national and regional databases and used to calculate fragmentation variables. The pre-selected variables were then filtered based on their correlations and their variance inflation factors to avoid multicollinearity. The final variables used are described in Suppl. material 1.

Brown trout occurrences, a total of 19,098 records from 48,076 samplings, were obtained from the Spanish Fish Chart*[1]. However, only samplings from the year 2000 onward and from the study area were retained (i.e., 27,391 samplings with 13,174 brown trout occurrences). Samplings performed through electrofishing where no brown trout were recovered were marked as true absences. Samplings from the same river segment were aggregated into a single presence-absence record, considering a single occurrence as evidence of presence. Presences and absences were balanced to avoid prevalence issues. After all this processing 4,344 presences and 4,344 absences were retained to model brown trout distribution. Eighty percent of the data was used to train the SDMs and the remaining 20% was further divided into two test datasets, each containing 10% of the data.

SDMs were produced using the R package Biomod2 (Thuiller et al. 2025). Eleven sets of SDMs were built depending on the variables included. One of the sets included only the environmental variables and the 10 remaining sets of models included the environmental variables and one of the 10 fragmentation variables. For every set, individual models were built first and then used to create ensemble models. Their performance was evaluated using the first and second test datasets respectively, and measured through the Area Under the Curve (AUC) of a receiver operating characteristic curve and the True Skill Statistic (TSS).

The base model (i.e., the ensemble model that only included environmental variables) had an AUC of 0.911, and a TSS of 0.673. The ensemble models that included fragmentation variables had a significantly better performance on average than the base model (Fig. 1). The most important variables to explain the species' distribution were consistently climatic related to rainfall (LCP) and temperature (BFMEDT) (Suppl. material 1).

The highest metrics (i.e., AUC = 0.915 and TSS = 0.689) were obtained by the ensemble model incorporating the variable DistUpDwnN, which can be interpreted as the minimal barrier-free distance. According to the model's results, the brown trout is mainly distributed in the north of mainland Spain (Fig. 2), a distribution that is favorable to its environmental requirements. However, this model predicted a decreasing probability of occurrence as the minimal barrier-free distance increased, which is probably an artifact of the river segments in the north tending to be shorter and more fragmented.

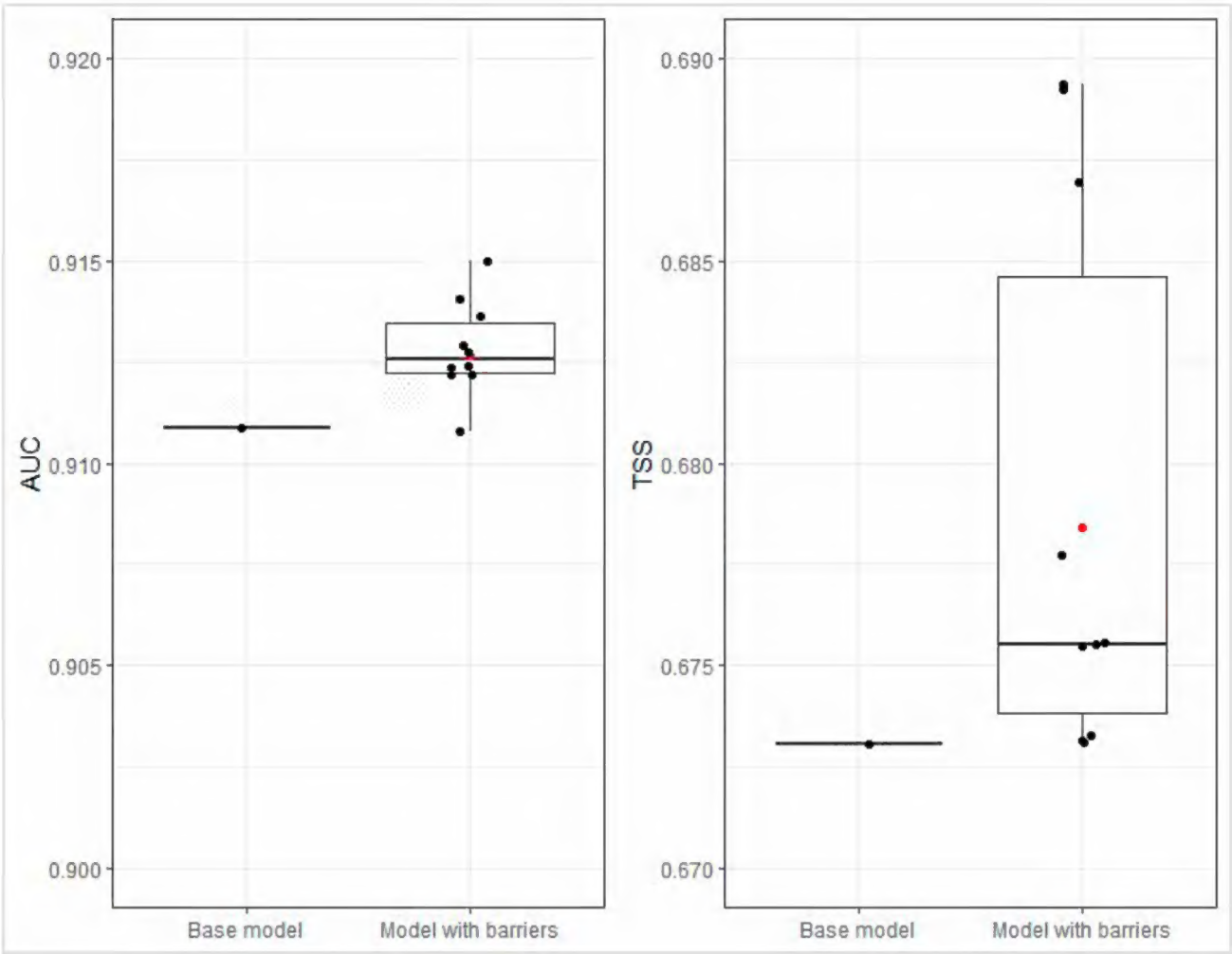

Figure 1.

Comparison of the performance metrics (AUC and TSS) of the base model and the ensemble models with fragmentation variables. The red dot represents the mean performance. CC BY-NC 4.0.

Keywords

species distribution models, river barriers

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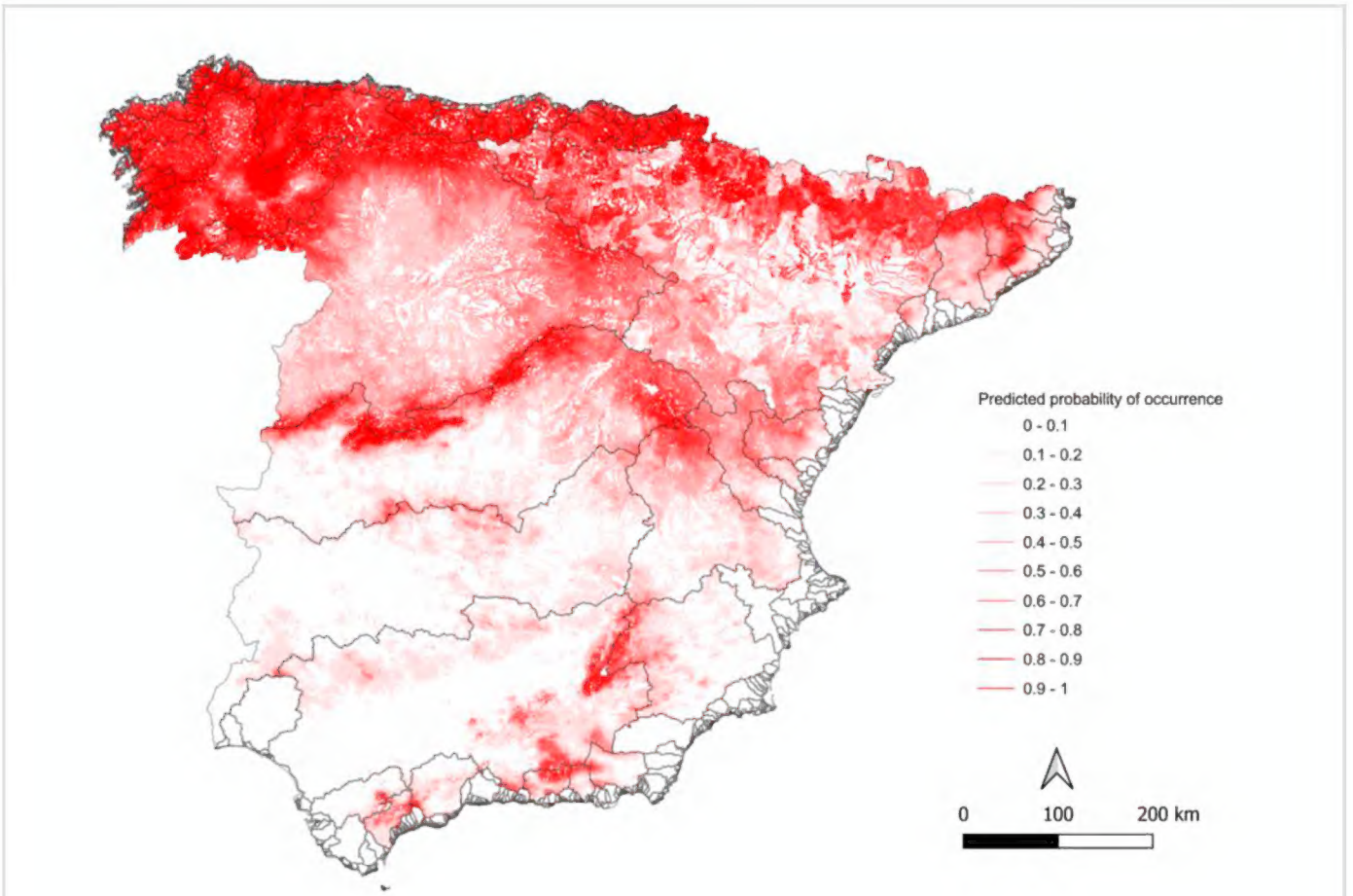

Figure 2.

Predicted probability of occurrence of the brown trout by the best performing ensemble model.

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Conflicts of interest

The authors have declared that no competing interests exist.

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Supplementary material

Suppl. material 1: Table S1 doi

Authors: Lide Izeta-Zalduendo
Data type: table
Brief description: Description of the variables included in the Species Distribution Models.
Download file (14.63 kb)

Endnotes

*1 https://www.cartapiscicola.es/